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(19) (CA) APPLICATION FOR CANADIAN PATENT (12)

(54) Gyro Stabilized Triple Mode Aircraft

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(71) Same as inventor

(57) 14 Claims

Notice: This application is as filed and may therefore contain an incomplete specification.

2195581

Gyro Stabilized Triple Mode Aircraft

Abstract

A triple mode aircraft which can take off as a helicopter, or in gyrocopter mode with no power to the rotors or as a conventional aircraft obtaining lift from a circular wing and in another embodiment from short stub wings; a canard wing and high lift tailplane. So it combines the flexibility of a helicopter with the same efficiency and safety of a gyrocopter and a fixed wing aircraft, also has the same simplicity and efficiency of flying a helicopter that doesn't have a tail rotor to worry about. The rotor craft includes two counter-rotating rotors with weighted tips on one set of rotors or a circular airfoil (CA) attached to at least one set of rotors. This CA gives the lift to function as a conventional aircraft, it also weights the tips of the rotor to give a gyro-stabilizing effect to the whole aircraft. Also there is a down draft rudder that functions as a rudder in horizontal flight or catches the down draft from the rotors for directional control. There is a conventional horizontal tail with elevator controls which can be differentially operated for additional control.

Claims:

1. Structure for enhancing the performance of a helicopter main rotor, comprising: A thin substantially planar annular airfoil having a chord of up to 20% of the rotor radius and a thickness about 15% of the airfoil chord and a central opening with a diameter slightly greater than the diameter of the rotor; and Attached to the rotor blade in line with or slightly down stream from and coaxial with the rotor blades and in a plane essentially parallel to the plane of the rotor, for capturing vortices produced in the wash of the rotor blades; for sheltering the rotor blades thus reducing air resistance while in forward flight; for increasing lift; for acting the same as a fixed wing while in forward flight; for tying the rotor blades together so they work together more like a disc; also, so the x distance shown in fig. 1 can be reduced, thus further enhancing the lifting efficiency of the counter rotating rotors; which because of the added flow, would, through the synergistic effect, increase the lift of the CA. Also for providing Gyro stabilization to the aircraft.
2. The structure recited in claim 1 wherein the cross section of said airfoil has a cambered configuration. Also in the preferred configuration the shape would be similar to that shown in fig.3, i.e. similar to that of the aerobie. The cross section of said airfoil is uniform all around the circle i.e. the chord will be the same all around the circular airfoil and will give equal lift no matter what radial direction, the edge of the circular airfoil is moving. In addition to the preferred cross sectional shape mentioned above it could have a shape like an NACA 00012 or NACA 23015 i.e. fairly thin with little wind resistance but in another embodiment it could have a thicker cross section for slower speed very stable operation.
3. A method for enhancing the performance of a helicopter main rotor, comprising the steps of: directing the downwash produced by the main rotor through the circular opening in the structure mentioned in claim 1 capturing the vortices at the tips of the rotors. Thus stopping the interference caused by the air re-circulating from down below the rotors and short circuiting back up to the top of the rotors as illustrated in fig. 4 . Thus allowing more air to be drawn across the circular airfoil (shown at z in fig.4, causing additional lift, and moving down through the center of circular airfoil, displacing more air and enabling the rotors to also be more efficient & giving more lift, less vibration and less noise.
4. The method recited in claim 3 including the step of drawing additional air across the upper surface of said airfoil as well as from the region adjacent to the downstream surface of said airfoil to reduce boundary layer build up, thus enhancing the lift of the airfoil.
5. With the structure recited in claim #1 giving Gyro stabilization and equal lift in what ever radial direction its flying , this permits us to claim another innovation i.e. flat turns versus normal banking turns which further simplifies the operation of this aircraft.
6. The circular airfoil recited in claim 1 which ties the rotors together so they act more like a solid disc is the method by which we are able to reduce spacing between rotors x distance indicated in fig.1 which increases lift efficiency & reduces the height of the aircraft.
7. The structure recited in claim 1, i.e. the CA, gives the aircraft the stability and versatility (can operate in three modes) that it allows us to change an age old method of flying, i.e. flat turns (as recited in claim 5) and no throttle operation; which gives the following Simplifications : flat turns versus needle and ball banking turns ;one speed for normal operation of rotors and forward thrust propeller (i.e. a simple automatic control just like a cruise control) . In other words for normal operation, you don't have to touch the throttle, you just have to use the pitch controls for the rotors and the propeller along with the rudders ; and maybe the stick control at times for the flaperons (to

use as a trim control). In other words both for flying and for maintenance it is simpler ; i.e. none of the controls and equipment for the tail rotor are necessary, nor the cyclical controls and with the whole aircraft being a Gyro stabilized platform the simplicity of just up, down, and turn, type of operation make it a real possibility for simple auto-pilot operation.

8. Reduced noise level compared to a conventional helicopter caused by interference of the rotor vortices and the high speed tail rotor vortices and also the noise caused by the chopper rotor blades cutting their own sound waves during high speed forward flight, because with this invention the rotor blades, during high speed forward flight, are either feathered or almost feathered. Also the noise caused by cyclical operation is eliminated.
9. High speed capability greater than conventional aircraft because this invention overcomes the standard problems with conventional helicopters 1) unequal lift due to different airspeeds of the wind over the rotating rotors. 2) Drag due to high pitch angle of blades and due to the drag caused by the rotor tilted into the wind to give forward flight (versus flat level rotors with feathered blades), this is possible because of the circular airfoil acting like a fixed wing and giving the required lift, allowing the majority of the power to be used to drive the propeller for forward thrust.
10. The structure recited in claim 1 (CA giving Gyro stability) and the method of operation (flat turns) gives better and consistent operation visibility.
11. The structure recited in claim 1; along with twin engines and drive systems; the projectile launched parachute system ,12, and the method of operation (Gyro stabilized ; flat turns; no need for throttle control; the circular airfoil which protects a projectile launched parachute system; and the almost zero need for use of the stick control) will make this invention the safest airplane on the market as explained in the following. It has been stated by many experts that a large majority of gyroplane accidents have been caused by pilot induced oscillation (this is also true of some helicopter accidents), this is caused by over controlling on the stick. Since, because of Gyro stability and new method of operation (flat turns), their will be almost zero need to use the stick, that should eliminate these accidents. Many other accidents are caused by stalling in bank turns and improper use of throttle control. These two functions are unnecessary, therefore these accidents should be eliminated. The dual engine and drive systems give enough redundancy to eliminate, engine and drive system failure, caused accidents. Perhaps the biggest advantage of all, of this invention , as far as safety is concerned, is the fact that the circular airfoil will stop the projectile launched parachute from being entangled or cut by the rotors. Therefore in a last ditch, emergency situation, the pilot could launch a parachute that would give pilot, crew and aircraft a soft landing.
12. A structure similar to that recited in claim 1 and shown in fig. 1 & 2 as 5 , this structure would be much smaller and lighter than 4 and when used the primary function would be to connect the blades in that set of rotors and make them function more like a disc but it would also function in a similar fashion to that claimed for 4 , above, but to a lesser extent, being smaller.
13. The structure recited in claim 1, along with the other claims recited on new methods of operating this invention make this aircraft more simple and easy to fly than any prior art , particularly as a helicopter.
14. The claims recited in 1 and in 12 and in the new methods of operation recited above enable this invention to be more versatile than any prior art. Specifically it can function as a very easy to fly, easy to maintain helicopter; gyroplane and fixed wing airplane; in other words it is a convert-a-plane that can convert to any of the three cited modes while flying .

Background of the Invention

Rotary wing aircraft such as helicopters have found many application due to the vertical flight and hovering capabilities of such craft. These capabilities are achieved through the use of rotary wings, i.e., rotor blades having an airfoil cross-section. As used herein, the term "airfoil" refers to shapes capable of generating lift due to airflow thereabouts from a leading to a trailing edge. Rotary wing aircraft are thus capable of generating lift even in vertical flight or while hovering because the rotary motion causes airflow about the surfaces of the rotary wings.

A disadvantage of conventional rotary wing aircraft, i.e., helicopters employing a single main rotor blade assembly in their principal lift generating system, is that such aircraft generally employ a heavy and power consuming tail rotor for torque compensation and yaw control. Torque is exerted on conventional rotary wing aircraft due to the rotation of the main rotor blade assembly which would result in rotation of the aircraft body if not counteracted. Typically, this torque is counteracted by use of a tail rotor which generates a torque equal but opposite to that of the main rotor blade assembly. The pitch of the tail rotor blades may also be adjustable to vary the torque generated by the tail rotor thereby providing helicopter yaw control. Thus, in conventional helicopters, a significant amount of power and weight is dedicated to the tail rotor for torque compensation and yaw control. This extra mechanism makes it far more difficult to fly and to maintain. This also makes the aircraft more unsafe not only because its harder to fly, but also because the spinning tail rotor could strike someone or something.

Another disadvantage of conventional rotary wing aircraft is the inefficiency and complexity of forward flight relative to fixed wing aircraft. In conventional rotary wing aircraft, a forward thrust is provided by angling the main rotor blade assembly relative to vertical so that a component of the force generated by the assembly is directed forward. By contrast, in a fixed wing aircraft, substantially all of the force generated by a propulsion assembly, such as a propeller or a jet engine, may be directed to provide a forward thrust.

In addition, conventional rotary wing aircraft generally employ a cyclical pitch control assembly to compensate for varying relative air speeds experienced by the rotor blades in forward flight. In rotation the rotor blade has an advancing portion, where the blade is rotating into the "wind" resulting from forward movement of the aircraft, and a retreating portion where the blade is rotating away from the wind. The speed of air relative to a rotor blade section and the force generated by the section in forward flight depends in part upon two components: the speed of forward flight and the speed of the rotor blade section due to rotation of the rotor assembly. As can be understood, these components will be generally additive during the advancing portion of a rotation and generally subtractive at the retreating portion. A

complicated cyclical pitch assembly is generally employed in conventional rotary wing aircraft to vary the pitch of the rotor blade over a rotation cycle so that a substantially symmetrical lift and thrust distribution results. To facilitate forward flight, the rotor of conventional rotary wing aircraft is therefore complex in design and operation and generally inefficient in comparison with fixed wing aircraft. Another disadvantage is that it is very difficult if not impossible to use a propulsion launched parachute to afford a soft landing ,in an emergency, for pilot, crew and aircraft.

Thus, it would be advantageous if the positive attributes of fixed wing and rotary wing aircraft could be combined. Desirably, such a rotary wing aircraft could combine the hovering and vertical flight capability of rotary wing aircraft with the efficiency and simplicity of fixed wing aircraft in forward flight. Additionally, such a craft could preferably eliminate the need for a tail rotor to compensate for rotary wing torque thereby enhancing aircraft weight and power efficiency. Also great advantages would be attained if the aircraft had gyro stability, in that it would be a smoother, safer, flying platform. Further efficiencies would result if such a craft were provided with a fixed wing capable of generating lift in both forward and vertical flight. Finally a further and most important advantage would be attained if this aircraft could have the redundancy of two drive mechanisms and power plants either of which could safely fly the aircraft if one system failed; could be landed by auto-rotation or by use of the fixed wing and further if all systems failed could be landed safely by the use of a parachute (aircraft, occupants, and all).

Brief Description of the Sketches

Fig. 1 is a perspective diagrammatic view of the preferred embodiment of a triple mode aircraft constructed in accordance with the teachings of this invention. Please note this sketch shows a stub wing which partially houses the wheels, 2, and flaperons , 11&11'. This is not necessary in the preferred embodiment and is shown merely to indicate another embodiment.

Fig. 2 is a top plan view of the aircraft shown in fig. 1 with the top rotor shown in cross-hatching and the optional top circular airfoil also shown cross-hatched.

Fig. 3 is a cross-sectional view of section A-A from fig. 1, it shows an "aerobie" type airfoil, indicating the direction of travel of the aircraft, the general flow pattern of the air over the circular airfoil (CA) i.e. after leaving the leading half of the CA the air is directed down on the trailing half of the CA, thus putting a downward force on the trailing portion of the CA and also reducing the lift because of the direction of flow. However the shape of the airfoil corrects the unbalance of lift between leading and trailing half of the CA; as indicated at point 24 on the leading half, the shape of the airfoil acts like a spoiler and reduces the lift of the leading portion of CA. Whereas illustrated on the trailing half at corresponding point 24 , with the air movement in reverse, the shape of the airfoil acts like, a high lift flap, giving an increased lift. Thus the circular airfoil now would have equal lift all around and even when spinning as a Gyro it would not be forced up 90 degrees to the leading edge (which is a Gyros built in reaction). Thus this "aerobie" shape airfoil tends to solve this down wash airflow problem.

Fig. 4 is two cross sectional views B-B & B'-B' from fig.2, it shows the pivot point 16 between CA 4 and rotor blades 3, it also shows the air forced down by the rotors and CA (labeled, down draft) and the vortices at point y caused by the tips of the rotor blades and blocked by the circular airfoil, this blocks short circuiting of the air from the bottom of the rotor to the top, thus the efficiency of the rotors is increased and more air is moved down, which causes more air to be drawn across the lifting surface of the CA at point z and improving it's efficiency, giving the two of them, working together, a synergistic effect

Fig's 5&6, side and top view respectively, are another embodiment, illustrating, tractor propeller, 6 , skids instead of wheels, 2', the rotors and CA mounted below and the engine exhaust deflector, 28, which can give yaw control .

Fig's 7&8,side and top view respectively, are another embodiment but without the circular airfoil, instead some rotor tips are weighted to give the Gyro stability, and in order to obtain sufficient lift and control for high speed forward flight a canard wing is added, 22 , with flaperons, 23 & 23';louvers,28, for exhaust gas yaw control also de-tent mechanism, 25 , shown holding rotors, 3&3', in the preferred position, for high speed, forward flight. Also in this embodiment a stub wing (not shown in this sketch but similar to that shown in fig. 1) may have to be added to have sufficient lift in high speed forward flight, when rotors would be feathered, for less drag.

Fig.9 is a partial, side view of fig. 8 with the stub wing added showing the control surfaces (9', 11', 23', as well as louvers,28)

Description of the Preferred Embodiment

Fig. 1 shows a triple mode aircraft or rotor craft 20, capable of flight in helicopter mode (with powered counter-rotating, synchronized, rotors) also in the fixed wing type mode where the CA does the same job as a fixed wing, whether fixed or rotating. In the third mode it can fly as a conventional gyrocopter with the propeller (pusher or tractor type) affording the forward propulsion and the rotors freewheeling and giving the vertical lift, in addition the rotors can be pre-rotated to an acceptable speed and then turned loose to free wheel, which will store up sufficient energy with the help of the CA momentum to give a jump start takeoff. It could be landed in like fashion as a standard gyrocopter with a rolling landing or vertical takeoff using the stored energy in the CA. Because of the helicopter capability, it should be noted, that about the only time it would be advantageous to fly in the gyrocopter mode would be for training pilots how to fly a conventional gyrocopter (with auto-rotation, etc.) and if the rotor drive system should happen to fail then it could be flown and landed as a standard gyrocopter; also as a conventional aircraft using the horizontal propeller for power and the CA for lift.

The aircraft 20 includes a fuselage 21, which is suspended from coaxial, counter-rotating, synchronized, rotors, in pendulum fashion (while flying) this suspension is mounted on a gimbal system with controllable pitch rotors and a mast that is universally movable in any direction, for control. The rotor blades 3' on the top rotor and 3 on the bottom have three blades each, in the preferred embodiment, these blades are rigid, short blades and can be symmetrical in configuration, permitting the rotor/wing to operate effectively irrespective of the flow direction. These blades can have attached to them as shown circular airfoils 4 and 5 which give the gyro stabilization for the aircraft and also store energy for jump-start takeoffs in the gyro mode and vertical lift in high speed fixed wing type mode. The aircraft can be powered by wankel engines or turbines as well as other types 15 and 15', particularly if it is turbines, louvers can be installed in the aerodynamic hub fairing to help in the yaw control of the aircraft, possibly eliminating the rudder controls. Additionally the swivels at both ends of the rotor blades 16, allow the pitch to be controlled as with a conventional helicopter. The rotor controls consist of cyclic and collective pitch controllers contained within an aerodynamic hub fairing 19. These provide the option of control of the aircraft in helicopter flight however because of the gyro stabilization effect of the circular airfoil attached to the rotor the cyclic control is normally not required. Yaw control is achieved through the combination, down draft/ standard type, rudders 7, and/or the louver control, 28, from engine exhaust. There is very little yaw stabilization necessary because of the counter-rotating rotors which cancel out the normal torque effect in a helicopter. Therefore a substantial efficiency is obtained over a standard helicopter. The fixed wing, horizontal flight mode is identical to helicopter mode and is reached when the aircraft obtains a vertically stabilized speed caused by the horizontal propeller 6, and the CA 4 and/or 5 (assisted by the high lift flaperons 11 and 11' , on the stub wings, when installed), and the high lift flaperons on the horizontal tailplane 9 and 9', in this particular embodiment. It should be noted, however, that another embodiment could be without stub wings and/or flaperons,11 &11'. The controls that can assist in this mode are the cyclic rotor control and the roll & elevator control, achieved through differential deflection of flaperons 11 and 11' and 9 and 9' on both the stub wings and the tail plane. The rotors can be stopped in position shown in fig. 8 by the existing drives and held in that position by a de-tent (de-tent and spring controlled cam apparatus). This position

can give better lift configuration (with reverse pitch settings) in the alternate embodiment and less drag in the long range, high speed, forward flight mode, in the preferred and alternate embodiment. However, even though these rotors are short and rigid they do have a limited bending moment when not rotating. Though the design structure is built in, it is possible that in practice this fixed position may only be used while on the ground; during run-up, taxiing or in emergency situations.

Functional description of the invention:

It will have twin counter rotating rotors (which eliminate the need for a tail rotor) one of the rotors will have mounted on it a circular airfoil (which will do a number of things, first it will weight the tips, giving the aircraft Gyro stability, second it will give the aircraft lift no matter which direction it turns or moves, in the horizontal, also it will tie the rotors together helping them to function more like a single disc, and it will have a synergistic effect, improving the lift characteristics of both the rotors and the CA). The second CA shown as 5 in fig. 1 could be a very small light weight structure compared to the primary CA, mostly to act as a tie to make that set of rotors more rigid and also function more like a disc. Because these rotors would be weighted less than the others the Gyro effect of the counter rotated rotors would not cancel out. To take advantage of this, the vertical take off and land (VTOL) aircraft will normally be flown like a flying saucer, i.e. it will not bank in a turn like a normal aircraft or helicopter, instead it will just rotate in the vertical plane and fly in the new direction. It will have twin engines and a twin drive system, the engines will have a speed control so after warm up with the speed control on, the rotors and the propeller will normally stay at the same speed thus maintaining Gyro stability and simplifying operation. To make turns more comfortable for pilot and passengers the seats could swing over like a pendulum in a turn. In helicopter mode it will clime or descend by changing the pitch on the rotors and the forward speed will be varied by changing the pitch on the propeller, 6. Therefore it will normally fly using only the three controls, rudder and two pitch controls. However it will have a cyclical stick to tilt the mast in case it happens to move (precess)(which can happen with Gyros when an external force is exerted on the Gyro) (which in this case is the circular airfoil); instead of using the stick the flaperons could be used for this small trim function. This stick could also be used if a pilot wanted to fly it like a standard gyro-plane or helicopter for training purposes. In normal operation these controls would be used infrequently therefore the wear & tear and maintenance on them would be minimal. The flaperons ,11 & 11' and 9 & 9', when installed would function in the first few degrees of the stick control, before the mast begins to move and would act like trim controls. This aircraft would be very easy to operate by radio control because of the, built in, Gyro stability, and because there would only be the three controls in normal operation i.e. pitch for elevation, pitch for speed and rudders for direction, the other control that would be need at times would be the flaperons.

One advantage of this design is the flexibility allowed so that if the manufacturer wanted to sell a starter model it could do so by building an alternate version like that shown in fig's. 7&8 without the circular airfoil and at a later date add the CA. There would be some disadvantages for example without the CA the spacing as indicated in fig. 1 as, x , would have to be increased because without the CA the individual rotor blades would act more independent and less like a solid disc as illustrated in fig. 1, in other words the CA ties the three rotor blades together so one tends to support the other. Also the fig.8 version would not convert to the more efficient, high speed, forward mode as efficiently, or at as low a speed, because of less lift without the CA; and at high speeds it would not have the CA to hide the rotor blades from wind resistance. Also because the rotors could not likely be feathered all the way, causing more resistance. Flat turns would be more difficult because again the airfoils would not act as much like discs and give equal lift no matter what direction it's moving through the air. However it would be cheaper and still function in the three modes.

The invention described and claimed herein is useful for various applications. It has application for all missions requiring vertical takeoff and hover capability. It is also suitable for military transport, attack, scout, and liaison missions. It could be used as a Navy aircraft operating from smaller ships other than aircraft carriers. Additionally, this aircraft could easily be adapted as a remotely piloted vehicle with

various military and commercial applications. Commercially, it would be a useful transport aircraft, particularly as a commuter or general aviation/business aircraft, and for aerial surveillance. The concepts of Gyro stabilization, no tail rotor, ease of flying, safety and high-speed capability make this aircraft more attractive than previous high-speed rotor craft concepts.

Although exemplary embodiments of the invention have been shown and described, many changes, modifications, and substitutions may be made by one having ordinary skill in the art without departing from the spirit and scope of the invention. Therefore, the invention is not to be limited except by the scope of the claims.

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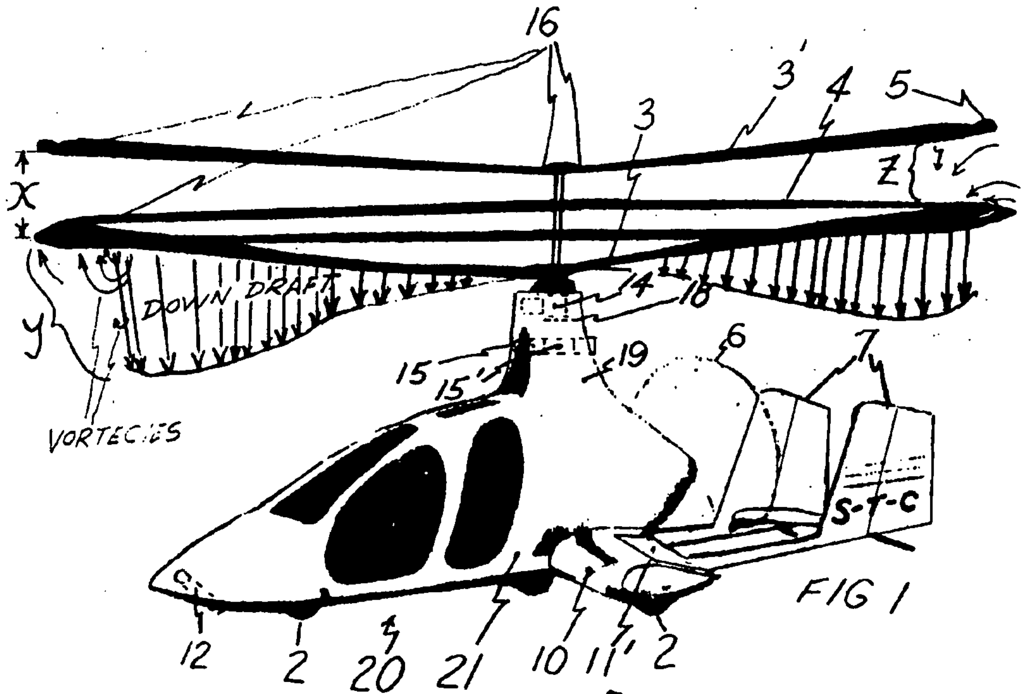

FIG 1

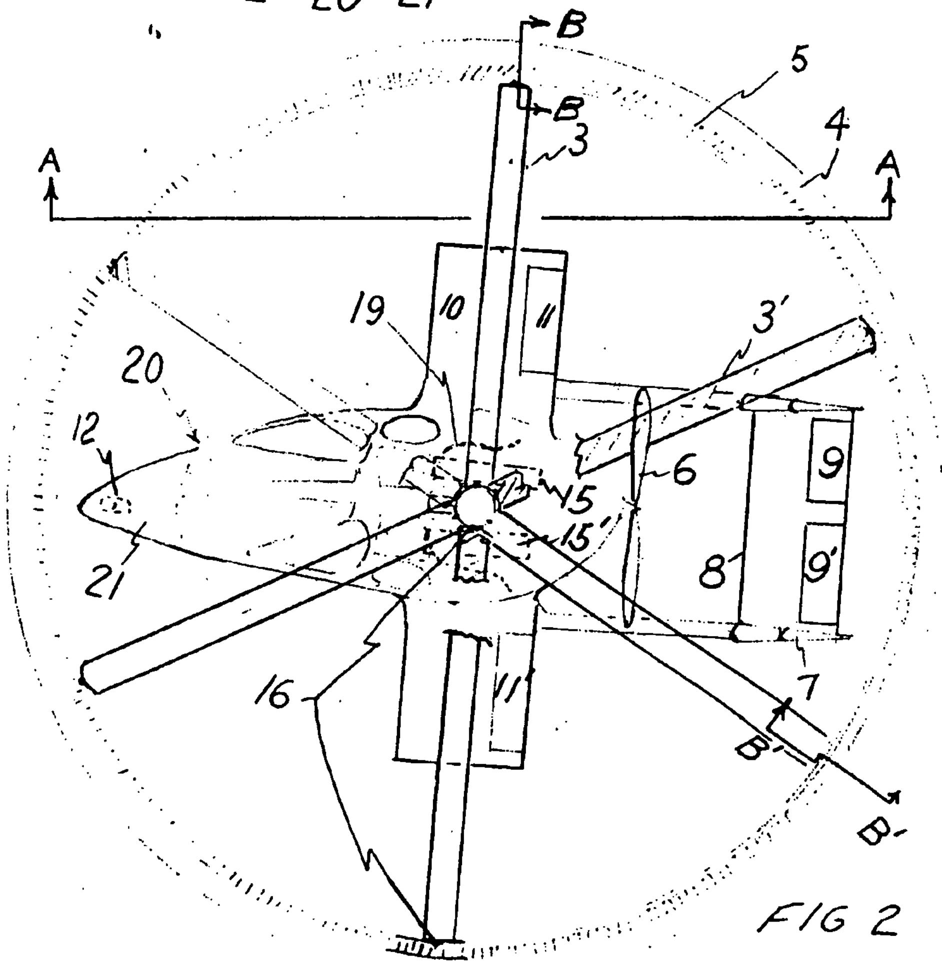

FIG 2

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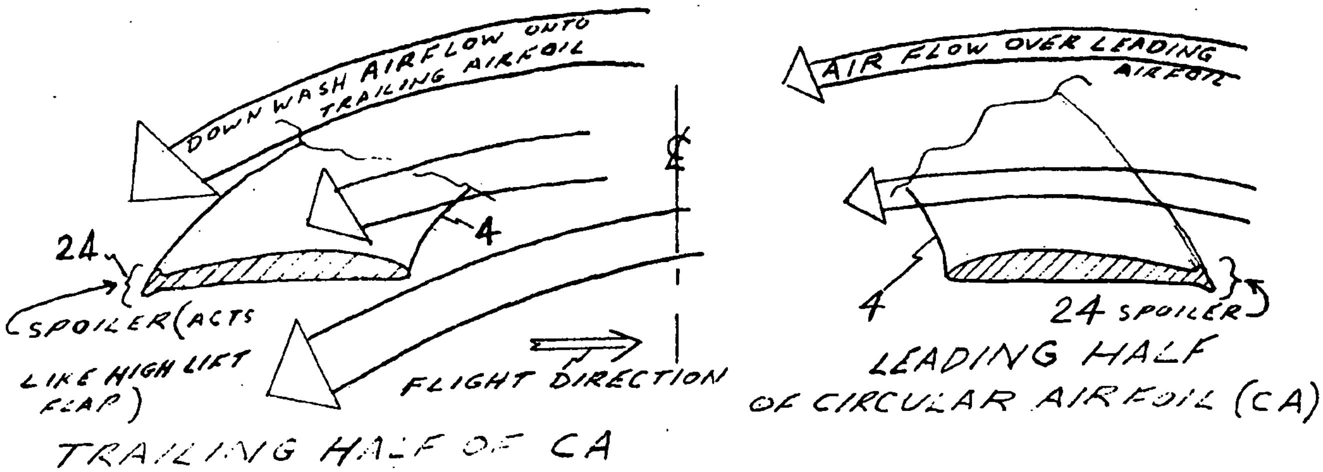

FIG 3
SECTION A-A

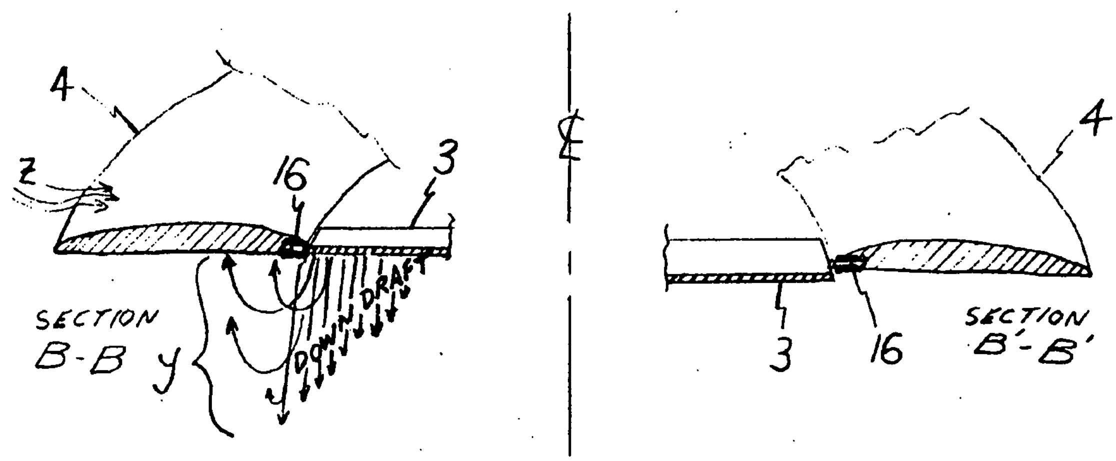

FIG 4

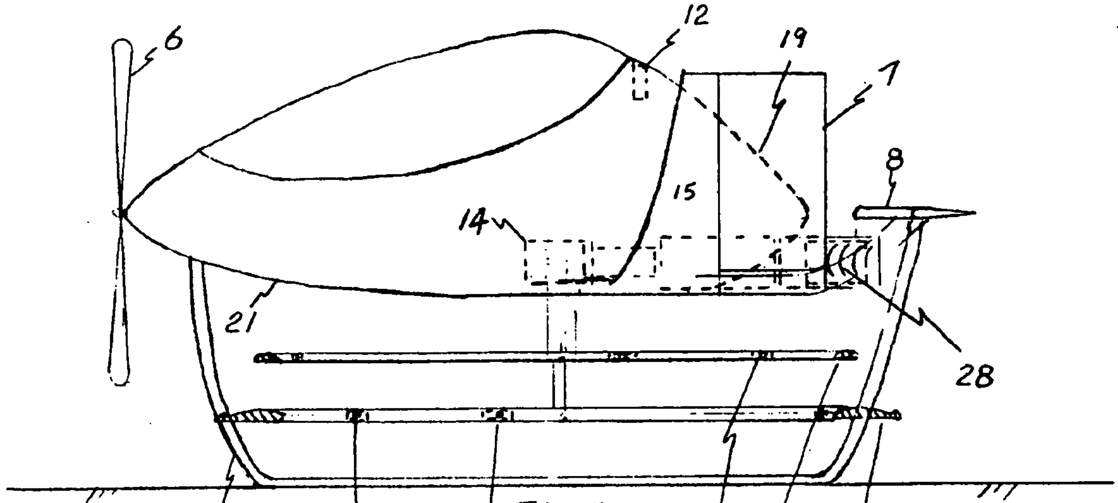

FIG 5

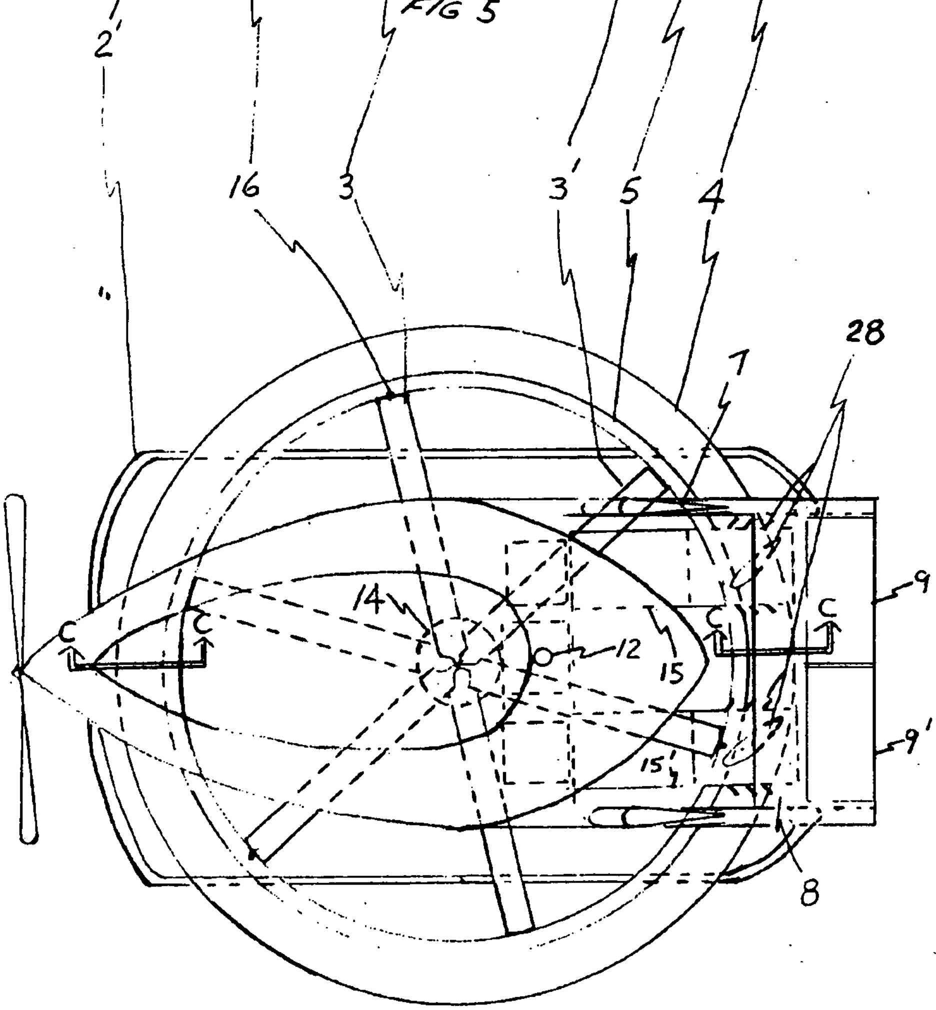

FIG 6

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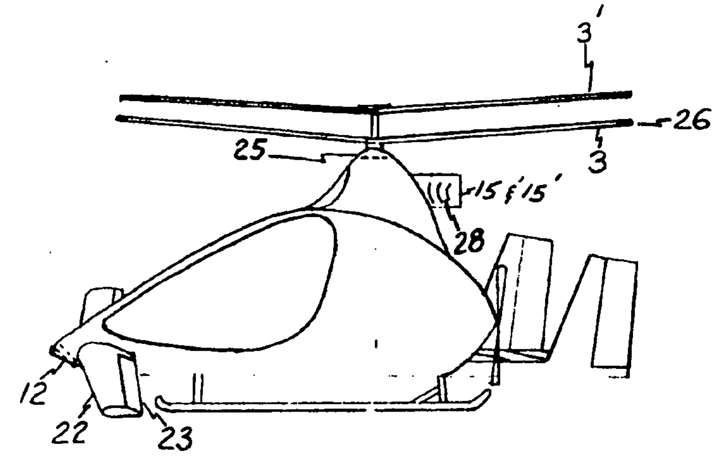

FIG 7

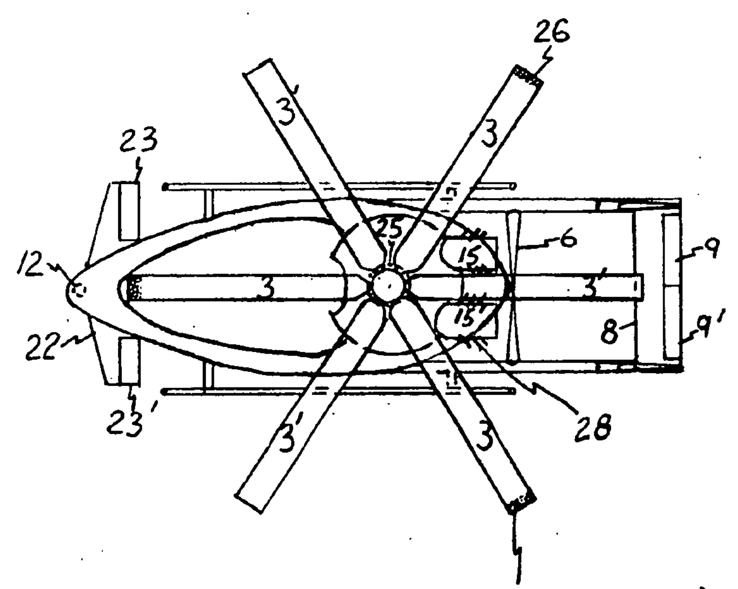

FIG 8

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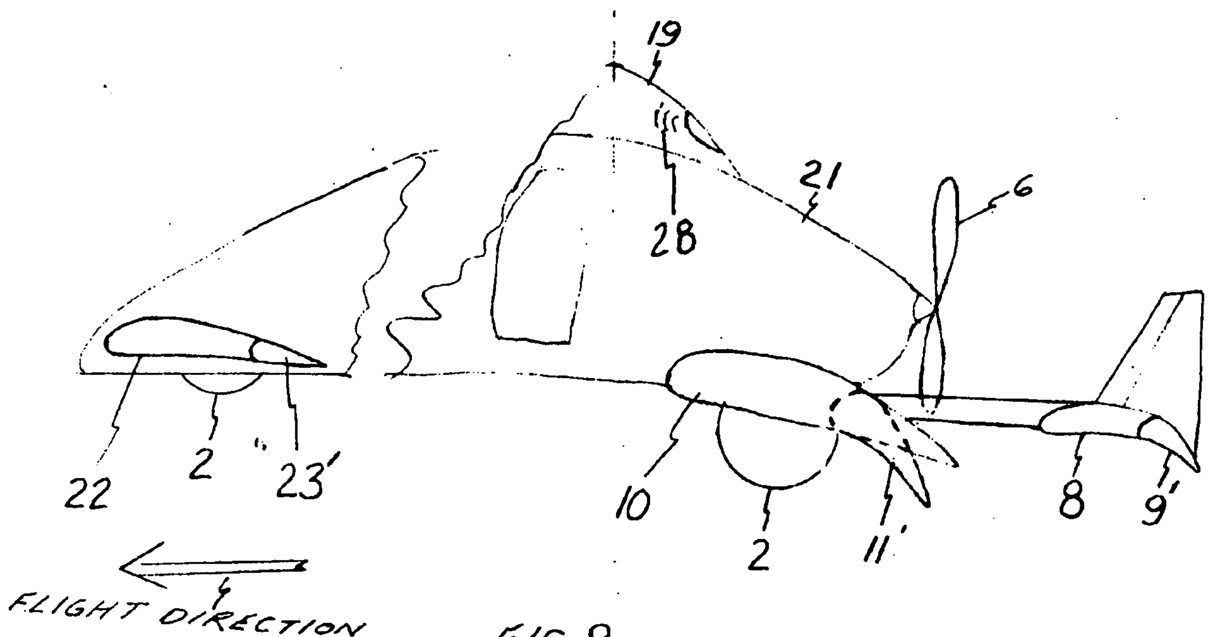

FIG 9